

**What Is Claimed Is:**

1           1.       A method for communicating between a first semiconductor die  
2       and a second semiconductor die through optical signaling, comprising:  
3           converting an electrical signal into an optical signal using an electrical-to-  
4       optical transducer located on a face of the first semiconductor die;  
5           wherein the first semiconductor die and the second semiconductor die are  
6       oriented face-to-face so that the optical signal generated on the first  
7       semiconductor die shines on the second semiconductor die;  
8           receiving the optical signal on a face of the second semiconductor die; and  
9           converting the optical signal into a corresponding electrical signal using an  
10      optical-to-electrical transducer located on the face of the second semiconductor  
11      die.

1           2.       The method of claim 1, wherein after generating the optical signal  
2       on the first semiconductor die, the method further comprises passing the optical  
3       signal through annuli located within metal layers on the first semiconductor die to  
4       focus the optical signal onto the second semiconductor die.

1           3.       The method of claim 1, wherein after generating the optical signal  
2       on the first semiconductor die, the method further comprises using a lens to focus  
3       the optical signal onto the second semiconductor die.

1           4.       The method of claim 1, wherein after generating the optical signal  
2       on the first semiconductor die, the method further comprises using a mirror to  
3       reflect the optical signal, so that the optical signal can shine on the second

4 semiconductor die without the first semiconductor die having to be coplanar with  
5 the second semiconductor die.

1           5.       The method of claim 1, wherein after generating the optical signal  
2 on the first semiconductor die, the method further comprises passing the optical  
3 signal through an interposer sandwiched between the first semiconductor die and  
4 the second semiconductor die, wherein the interposer contains one or more  
5 waveguides that direct the optical signal, so that the optical signal shines on the  
6 second semiconductor die.

1           6.       The method of claim 1,  
2 wherein the electrical-to-optical transducer is a member of a plurality of  
3 electrical-to-optical transducers located on the first semiconductor die; and  
4 wherein the optical-to-electrical transducer is a member of a plurality of  
5 optical-to-electrical transducers located on the first semiconductor die;  
6 whereby a plurality of optical signals can be transmitted in parallel from  
7 the first semiconductor die to the second semiconductor die.

1           7.       The method of claim 6,  
2 wherein multiple spatially adjacent electrical-to-optical transducers in the  
3 plurality of electrical-to-optical transducers transmit the same signal; and  
4 wherein electronic steering circuits in the first semiconductor die direct  
5 data to the multiple spatially adjacent electrical-to-optical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\theta$  coordinates.

1           8.       The method of claim 6,

2            wherein multiple spatially adjacent optical-to-electrical transducers in the  
3 plurality of optical-to-electrical transducers receive the same signal; and  
4            wherein electronic steering circuits in the second semiconductor die direct  
5 data from the multiple spatially adjacent optical-to-electrical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\Theta$  coordinates.

1            9.        The method of claim 1, wherein the electrical-to-optical transducer  
2 includes one of:

3            a Zener diode;  
4            a light emitting diode (LED);  
5            a vertical cavity surface emitting laser (VCSEL); and  
6            an avalanche breakdown P-N diode.

1            10.       The method of claim 1, wherein the optical-to-optical transducer  
2 includes one of:

3            a P-N-diode photo-detector; and  
4            a P-I-N-diode photo-detector.

1            11.        An apparatus for communicating between semiconductor chips  
2 through optical signaling, comprising:

3            a first semiconductor die;  
4            a second semiconductor die;  
5            an electrical-to-optical transducer located on a face of the first  
6 semiconductor die, which is configured to convert an electrical signal into an  
7 optical signal;

8            wherein the first semiconductor die and the second semiconductor die are  
9   oriented face-to-face so that the optical signal generated on the first  
10   semiconductor die shines on the second semiconductor die;  
11            an optical-to-electrical transducer located on a face of the second  
12   semiconductor die, which is configured to convert the optical signal received from  
13   the first semiconductor die into a corresponding electrical signal.

1            12.    The apparatus of claim 11, further comprising annuli located  
2   within metal layers on the first semiconductor die configured to focus the optical  
3   signal onto the second semiconductor die.

1            13.    The apparatus of claim 11, further comprising a lens configured to  
2   focus the optical signal onto the second semiconductor die.

1            14.    The apparatus of claim 11, further comprising a mirror configured  
2   to reflect the optical signal, so that the optical signal can shine on the second  
3   semiconductor die without the first semiconductor die having to be coplanar with  
4   the second semiconductor die.

1            15.    The apparatus of claim 11, further comprising an interposer  
2   sandwiched between the first semiconductor die and the second semiconductor  
3   die, wherein the interposer contains one or more waveguides that direct the optical  
4   signal, so that the optical signal shines on the second semiconductor die.

1            16.    The apparatus of claim 11,  
2   wherein the electrical-to-optical transducer is a member of a plurality of  
3   electrical-to-optical transducers located on the first semiconductor die; and

4            wherein the optical-to-electrical transducer is a member of a plurality of  
5 optical-to-electrical transducers located on the first semiconductor die;  
6            whereby a plurality of optical signals can be transmitted in parallel from  
7 the first semiconductor die to the second semiconductor die.

1            17.    The apparatus of claim 16,  
2            wherein multiple spatially adjacent electrical-to-optical transducers in the  
3 plurality of electrical-to-optical transducers transmit the same signal; and  
4            wherein electronic steering circuits in the first semiconductor die direct  
5 data to the multiple spatially adjacent electrical-to-optical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\Theta$  coordinates.

1            18.    The apparatus of claim 16,  
2            wherein multiple spatially adjacent optical-to-electrical transducers in the  
3 plurality of optical-to-electrical transducers receive the same signal; and  
4            wherein electronic steering circuits in the second semiconductor die direct  
5 data from the multiple spatially adjacent optical-to-electrical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\Theta$  coordinates.

1            19.    The apparatus of claim 11, wherein the electrical-to-optical  
2 transducer includes one of:  
3            a Zener diode;  
4            a light emitting diode (LED);  
5            a vertical cavity surface emitting laser (VCSEL); and  
6            an avalanche breakdown P-N diode.

1           20.     The apparatus of claim 11, wherein the optical-to-optical  
2 transducer includes one of:

3           a P-N-diode photo-detector; and

4           a P-I-N-diode photo-detector.

1           21.     A computer system including semiconductor chips that  
2 communicate with each other through optical signaling, comprising:

3           a first semiconductor die containing one or more processors;

4           a second semiconductor die containing circuitry that communicates with  
5 the one or more processors;

6           an electrical-to-optical transducer located on a face of the first  
7 semiconductor die, which is configured to convert an electrical signal into an  
8 optical signal;

9           wherein the first semiconductor die and the second semiconductor die are  
10 oriented face-to-face so that the optical signal generated on the first  
11 semiconductor die shines on the second semiconductor die;

12           an optical-to-electrical transducer located on a face of the second  
13 semiconductor die, which is configured to convert the optical signal received from  
14 the first semiconductor die into a corresponding electrical signal.

1           22.     The computer system of claim 21, further comprising annuli  
2 located within metal layers on the first semiconductor die configured to focus the  
3 optical signal onto the second semiconductor die.

1           23.     The computer system of claim 21, further comprising a lens  
2 configured to focus the optical signal onto the second semiconductor die.

1           24.     The computer system of claim 21, further comprising a mirror  
2 configured to reflect the optical signal, so that the optical signal can shine on the  
3 second semiconductor die without the first semiconductor die having to be  
4 coplanar with the second semiconductor die.

1           25.     The computer system of claim 21, further comprising an interposer  
2 sandwiched between the first semiconductor die and the second semiconductor  
3 die, wherein the interposer contains one or more waveguides that direct the optical  
4 signal, so that the optical signal shines on the second semiconductor die.

1           26.     The computer system of claim 21,  
2 wherein the electrical-to-optical transducer is a member of a plurality of  
3 electrical-to-optical transducers located on the first semiconductor die; and  
4 wherein the optical-to-electrical transducer is a member of a plurality of  
5 optical-to-electrical transducers located on the first semiconductor die;  
6 whereby a plurality of optical signals can be transmitted in parallel from  
7 the first semiconductor die to the second semiconductor die.

1           27.     The computer system of claim 26,  
2 wherein multiple spatially adjacent electrical-to-optical transducers in the  
3 plurality of electrical-to-optical transducers transmit the same signal; and  
4 wherein electronic steering circuits in the first semiconductor die direct  
5 data to the multiple spatially adjacent electrical-to-optical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\theta$  coordinates.

1           28.     The computer system of claim 26,

2            wherein multiple spatially adjacent optical-to-electrical transducers in the  
3 plurality of optical-to-electrical transducers receive the same signal; and  
4            wherein electronic steering circuits in the second semiconductor die direct  
5 data from the multiple spatially adjacent optical-to-electrical transducers to correct  
6 mechanical misalignment in  $X$ ,  $Y$  and  $\Theta$  coordinates.

1            29.    The computer system of claim 21, wherein the electrical-to-optical  
2 transducer includes one of:

3            a Zener diode;  
4            a light emitting diode (LED);  
5            a vertical cavity surface emitting laser (VCSEL); and  
6            an avalanche breakdown P-N diode.

1            30.    The computer system of claim 21, wherein the optical-to-optical  
2 transducer includes one of:

3            a P-N-diode photo-detector; and  
4            a P-I-N-diode photo-detector.